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[0001] MULTIUSER DETECTION OF DIFFERING DATA RATE SIGNALS

[0002] CROSS REFERENCE TO RELATED APPLICATION(S)

[0003] This application claims priority from U.S. provisional application no. 60/451,593 filed on March 3, 2003, which is incorporated by reference as if fully set forth.

[0004] FIELD OF INVENTION

[0005] The present invention relates to a wireless communications network, and more particularly, for multiuser detection in a frequency division duplex system.

[0006] BACKGROUND

[0007] Signals can be sent in frequency division duplex (FDD) mode as shown in FIG. 1, for example a plurality of voice signals (V1, V2, and V3) and a plurality of data signals (D1 and D2). The voice signals are transmitted typically at a lower power than the data signals, since the voice signals can be transmitted with a lower data rate (such as by a higher spreading factor) without a significant loss in signal quality. For example, a voice signal can be transmitted with a spreading factor of 64 (64 chips per data bit), whereas a data signal may be transmitted with a spreading factor of four chips per data bit, due to the higher transmission rate. As illustrated in FIG. 1, several voice and data signals can be transmitted in the same spectrum. For voice communications (V1, V2 and V3), the voice signals usually need a small amount of system bandwidth, and accordingly transmission power. For high rate data signals, a larger bandwidth is required which typically requires higher transmission power levels.

[0008] The uplink of the FDD universal mobile telecommunications system (UMTS) supports a potentially large number of simultaneously transmitted codes. The signature sequences of the codes are highly non-structured with long codes having a period of one frame (38,400 chips). Short signature sequences are permitted as an option; however, even these short sequences have a period of 256 chips. By comparison, in time division duplex (TDD) mode where multiuser detection techniques are more typically employed, the signature sequences are far shorter and more rigidly structured, with a period of 16 chips.

[0009] The lack of structure of the signature sequence in FDD combined with a large number of users that the receiver may be required to support makes it infeasible to implement standard multi-user detectors (MUDs), such as decorrelator and minimum mean square error (MMSE) type receivers in such systems. Other popular MUD receiver structures are not necessarily suitable here either. For example, successive interference cancellers (SICs) do not perform well with a large number of codes of approximately the same power. Parallel interference cancellers (PICs), are complex and do not necessarily deliver significant performance improvements because their effectiveness falls as the total interference rises. Accordingly, PICs tend to perform poorly for recovery of voice user data in the presence of several high data rate users.

[0010] Additionally, there is significant amount of data shuffling that occurs between the physical channel demodulation and the channel decoders. This makes joint channel demodulation and decoding techniques nearly infeasible.

[0011] Accordingly, it is desirable to have alternate MUD-type receiver designs for such systems.

[0012] SUMMARY

[0013] A first detector receives a received signal and extracts the data signals from the received signal. A hard decision converter converts soft symbols outputted by

the first detector into hard symbols. An interference canceller extracts the voice signals from the received signal. A second detector is connected to the output of the interference canceller, and extracts the individual voice signals. The second detector is a different detector type than the first detector.

[0014] BRIEF DESCRIPTION OF THE DRAWINGS

[0015] A more detailed understanding of the invention may be had from the following description of the preferred embodiments, given by way of example and to be understood in conjunction with the accompanying drawings, wherein:

[0016] FIG. 1 is a block diagram of an example FDD transmission block with multiple voice and data signals.

[0017] FIG. 2 is a simplified diagram of a transmitter and a receiver using a multiuser detector constructed in accordance with the present invention.

[0018] FIG. 3 is a block diagram of the multiuser detector shown in FIG. 2.

[0019] FIG. 4 is a flow chart of multiuser detection of differing data rate signals.

[0020] FIG. 5A, 5B and 5C are illustrations of reception blocks.

[0021] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] Hereafter, a wireless transmit/receive unit (WTRU) includes, but is not limited, to a user equipment, a mobile station, a fixed or mobile subscriber unit, a pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, a base station includes, but is not limited to, a base station, a Node-B, a site controller, an access point, or any other interfacing device in a wireless environment. Although the background refers to an FDD wireless system, the embodiments can be applied to various wireless systems, where both high data and low data rate services are transmitted in a shared spectrum.

[0023] FIG. 2 illustrates an embodiment of a multiuser detector as used in a wireless communication system operating in accordance with the present invention. A

transmitter 200 and a receiver 202 communicate with each other via a wireless radio air interface 208. The transmitter 200 may be located at a WTRU or at a base station. The receiver 202 may be located at the WTRU and/or the base station.

[0024] Data symbols to be transmitted to the receiver 202 are processed by a modulation and spreading device 204 at the transmitter 200. The modulation and spreading device 204 spreads the data with the codes and at a spreading factors assigned to the communications carrying the data. The communications are radiated by an antenna 206 or antenna array of the transmitter 200 through the wireless radio interface 208.

[0025] At the receiver 202, the communications, possibly along with other transmitters' communications, are received at an antenna 210 or antenna array of the receiver 202. The received signal is sampled by a sampling device 212, such as at the chip rate or at a multiple of the chip rate, to produce a received vector. The received vector is processed by a channel estimation device 216 to estimate the channel impulse responses for the received communications. The channel estimation device 216 uses a training sequence in the received communication to estimate the channel experienced by each communication. A multiuser detection device 214, uses the codes of the received communications and the estimated impulse responses to estimate soft symbols of the spread data.

[0026] As shown in FIG. 3, the multiuser detector 214 receives the sampled signal from the sampling device 212. The samples are provided to a blind adaptive detector 304 and a data buffer 306. The outputted soft symbols from the detector 304 are sent to symbol processing to recover the high data rate data (not shown in FIG. 3) and to a hard decision converter 310. After the hard decision converter 310, the signal is sent to an interference canceller 312, where the signals of the high data rate users are removed from the sampled signal (the high data rate users' signals are passed to the interference canceller 312 via the data buffer 306), leaving voice signals to be processed by a voice grade user detector 314.

[0027] Preferably, the blind adaptive detector 304, uses MMSE detectors for the high data rate users, although other detectors may be used. In one embodiment, the detector 304 is based on a blind adaptive multiuser detector (MUD), a constrained optimization approach, and array processing techniques. These techniques are used in order to deliver MMSE performance to all of the high data rate users.

[0028] The detection of the high data rate users is followed by an interference cancellation stage in which the estimated signals sent by these users are removed from the received signal by the interference canceller 312. The remaining signal typically consists of a large number of voice grade users. These voice grade users can be processed by using standard matched-filtering techniques, e.g., RAKE receivers. Alternately, a low-complexity detection scheme or parallel interference cancellation techniques may be applied. To reduce the complexity of the voice user detection, it is desirable to use simplier detectors, although more complex detectors may be used. To illustrate, in alternate embodiments, it may be desirable to utilize more complex detector that could be used for other purposes by the WTRU or base station. In one embodiment, the detectors 304, 314 are blind detectors and do not have complete knowledge of the received codes. These components can be implemented on a single integrated circuit, multiple integrated circuits, discrete components or a combination of them.

[0029] Figure 4 is a flow chart for differing data rate multiuser detection, and is explained with the illustrations of Figures 5A, 5B and 5C. The receiver receives both high data rate and voice signals in a shared spectrum, step 400. As illustrated in Figure 5A in terms of received power, two high data rate signals, D1 and D2, are received along with three voice signals, V1, V2, and V3, received along with three voice signals, V1, V2 and V3, and noise, N.

[0030] Preferably, a data detection is performed on the high data rate signals, step 402. Figure 5B is an illustration of the treatment of the spectrum by the detector 304. The detector 304 treats the voice signals as noise, N. The high data rate signals

can be determined by many means, such as by received power levels, *a priori* knowledge, etc. Since all of the signals are not processed by this detector, a lower complexity detector can be used. This is further facilitated by the detector 304 only processing high data rate signals typically having similar received power levels.

[0031] Using the symbols produced by the detector 304, the contribution of the high data rate signals is canceled from the received vector, step 404. After cancellation, the samples resemble Fig. 5C. As shown in Fig. 5C, the contribution of the high data rate signals, D1 and D2, is removed. A data detection is performed on the voice signals, V1, V2 and V3, step 406. If a detection of data signals V1, V2 and V3 was performed on the uncancelled signal of Fig. 5A, typically, D1, D2 and the noise would all be treated as noise and/or interference, instead of only the noise N as in Fig. 5C. For a typical implementation where high data rate services are being separated from voice services, the voice users are typically at similar power levels. Although the power levels for high data rate services may vary, these services typically have much higher power levels. Since data detectors typically perform better for equal power signals, the separation on the signals tends to improve performance.

[0032] The exemplary embodiment of the multiuser detector 214 provides three general functions: (1) support for a limited number of high performance high data rate users at a minimal cost to the basic (i.e., voice grade) capacity; (2) a low-complexity receiver that is effective for a large number of approximately equal power users (i.e., voice grade users); and (3) a receiver structure which supports a family of algorithms, rather than a single algorithm, so that certain parameters are adaptable to the specific needs of different potential customers. In alternate embodiments, some of the functions may be sacrificed in favor of other functionality.

[0033] While the description above partitions the users into two categories, data and voice, the partitioning is done because it is the natural partition for the application of third generation (3G) mobile telephony. The method itself is not limited to such

partitioning and more levels may be defined with data detection and successive interference cancellation used repeatedly at each level, as shown in FIG. 3.

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